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Tradeoffs between forestry resource and conservation values under alternate policy regimes: A spatial analysis of the western Canadian boreal plains

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ABSTRACT

An important element of resource management and conservation is an understanding of the tradeoffs between marketed products, such as timber, and measures of environmental quality, such as biodiversity. In this paper, we develop an integrated economic-ecological spatial optimization model that we then apply to evaluate alternate forest policies on a 560,000 km^2 study region of managed boreal forest in Alberta and British Columbia, Canada. The integrated model incorporates dynamic forest sector harvesting, current levels of oil and gas sector development, coarse-filter or habitat-based old forest indicators, a set of empirical forest bird abundance models, and statistical models of the natural and current fire regimes. Using our integrated model, economic tradeoff curves, or production possibility frontiers, are developed to illustrate the cost of achieving coarse-filter targets by a set time (50 years) within a 100-year time horizon. We found levels of ecological indicators and economic returns from the timber industry could both be increased if spatial constraints imposed by the current policy environment were relaxed; other factors being equal, this implies current policy should be revised. We explore the production possibility frontier's relationship to the range of natural variation of old forest habitat, and show how this range can be used to guide choices of preferred locations along the frontier. We also show that coarse-filter constraints on the abundance of certain habitat elements are sufficient to satisfy some fine-filter objectives, expressed as the predicted abundances of various species of songbirds.

1. Introduction

A quantitative understanding of the tradeoffs between marketed products and environmental quality is fundamental to sustainable management and biological conservation in managed ecosystems, such as our study region in the boreal forests of western Canada. Environmental services, such as biodiversity, are not traded in markets so their prices cannot be determined directly. Opportunity costs, measured by the monetary value of foregone resource development, can be used to estimate the costs of policy impositions intended to maintain various levels of environmental services, biodiversity, or similar non-market goods. The questions then arise: What level of environmental services is desirable? And at what time in the future will such a level be achieved? Answering these questions entails a social choice across the feasible set of alternatives for joint environmental and economic outcomes. The production possibility frontier (PPF) is that subset of feasible alternatives defined by the levels of different goods that can be obtained from a system under optimality, such that the level of no individual good can be increased without decreasing the levels of others. While PPFs can represent the tradeoffs between market and non-market goods and services that are feasible, it must be emphasized that they do not identify a "socially optimal" choice. Identifying a socially optimal point on the PPF requires an examination of people's preferences. We do not take up this question here. We use a spatial simulation model to estimate the PPF between revenue from forest management and indicators of biodiversity. We used the resultant PPF to quantify tradeoffs between biodiversity and forest products over a large study region of managed forest, located within the boreal plains ecozone (Ecological Stratification Working

Abbreviations: AAC, annual allowable cut; FMA, forest management agreement; FMU, forest management unit; NPV, net present value; PPF, production possibility frontier; RNV, range of natural variation.

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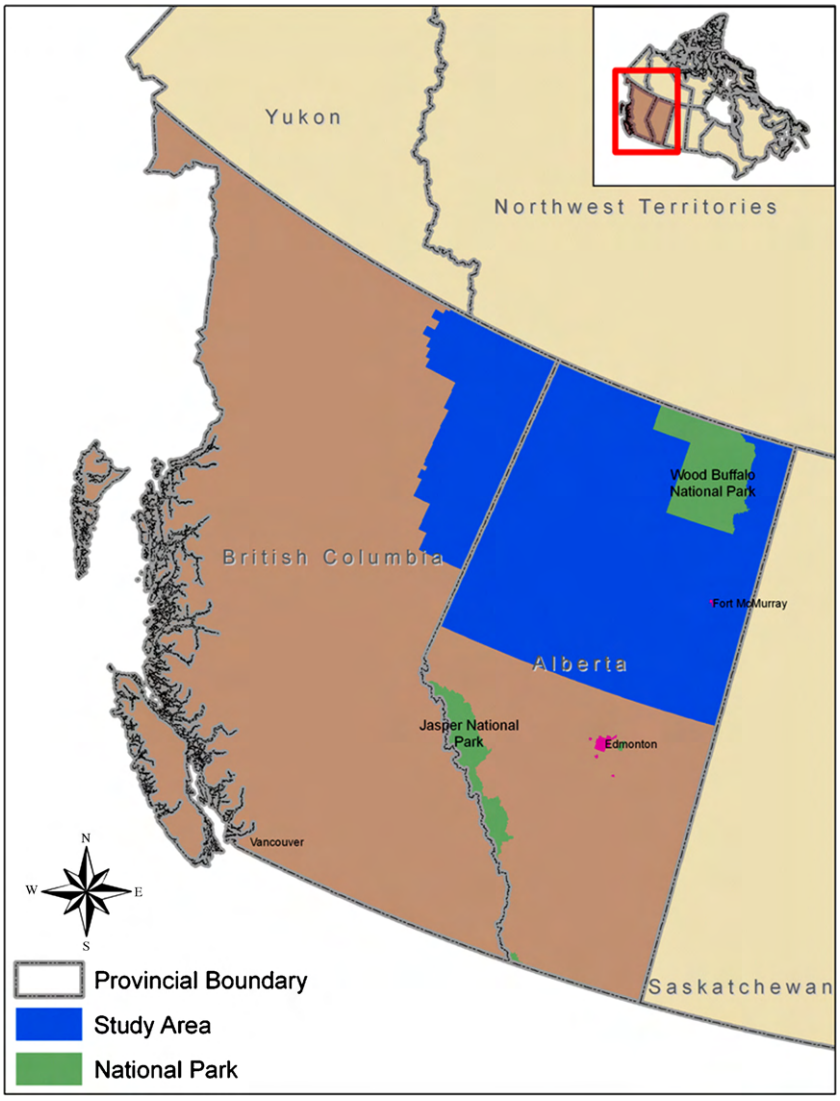

Fig. 1. Location of the study region in western Canada.

Group, 1996) in northern Alberta and northeast British Columbia, Canada (Fig. 1).

Others have applied PPFs to resource management and biological conservation in forest ecosystems. For example, Nalle et al. (2004) develops a PPF for the net present value of timber harvest and the populations of two species with conflicting habitat preferences. The authors use an unconstrained PPF to illustrate the costs of two management scenarios, the first concentrating conservation effort on public land only, and the second a static reserve selection problem. Both scenarios took spatial restrictions on timber harvests as given. In contrast, we focus on quantifying the effects of spatial constraints on the feasibility and economic cost of achieving conservation targets.

The development of integrated ecological and economic models to support policy decisions is critical in the context of government decision making on public forest land. As we illustrate below, the boreal forest plains provide a case study for examining the application of such tools. Several studies have examined a single economic agent (e.g., a forestry firm) that maximizes the net present value of forestry operations subject to constraints on alternative levels of the conservation goods. These agents respond to constraints by altering management variables, such as the optimal rotation age or the total area harvested (e.g., Armstrong et al., 2003; Marshall et al., 2000). However, these models lack spatial representation of both economic and ecological processes. Our study is based on a reformulation of a novel spatial modeling tool (Cumming and Armstrong, 2004) designed to represent ecological processes and economic activity over very large areas as well as across jurisdictional and administrative boundaries. The ecological components of the model include empirical models of the natural and managed fire regimes over the study region and models of the relative abundances of various species of forest songbirds. The economic component of the model represents the behaviors of many individual forest products firms, in particular their responses to changes in forest policy, markets, and the abundance and spatial distribution of resources.

The new contributions of this paper are as follows. First, we estimate the range of natural variation (RNV; Landres et al., 1999) in biodiversity indicators, an ecological concept used in forest policy in Canada (Burton et al., 2006), to identify ecologically defensible regions of the PPF and levels of the associated management actions. Second, we evaluate how spatial constraints consequent to government forest policies affect the shape and location of the tradeoff relationship. Third, we consider how changes in such policies may affect the ability to achieve acceptable environmental outcomes. Finally, the paper presents a new, integrated modeling tool we feel has significant potential for application to large-scale problems of management and conservation in the circumpolar boreal forest.